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COMPUTER BASED TEST (CBT) Memory Based Questions & Solutions

Date: 26 August, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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PART : MATHEMATICS

1. Sum of an infinite GP with first term a and common ratio r is 15 and the sum of the squares of the terms of the same GP is 150. The sum of an infinite GP with first term a and common ratio r^2 is :

- (1) $\frac{25}{2}$ (2) $\frac{1}{5}$ (3) $\frac{27}{5}$ (4) $\frac{23}{5}$

Ans. (1)

Sol. Given $\frac{a}{1-r} = 15$ (1)

$$\text{and } \frac{a^2}{1-r^2} = 150 \Rightarrow \left(\frac{a}{1-r}\right) \left(\frac{a}{1+r}\right) = 150 \Rightarrow \frac{a}{1+r} = 10 \quad \text{.....(2)}$$

solving equation (1) and (2)

$$r = \frac{1}{5} \therefore \frac{a}{12} \text{ from equation (1)}$$

Now, $a + ar^2 + ar^4 + ar^6 + \dots \infty$

$$\Rightarrow \frac{a}{1-r^2} = \frac{a}{(1+r)(1-r)} = 10 \times \frac{1}{\frac{4}{5}} \Rightarrow \frac{25}{2}$$

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2. If $(1+x)^{20}$ is expanded in the form of $\sum_{r=0}^{20} {}^{20}C_r x^r$, then the value of $\sum_{r=0}^{20} r^2 {}^{20}C_r$ is:

- (1) $2^{20} \cdot 105$ (2) $2^{18} \cdot 105$ (3) $2^{19} \cdot (205)$ (4) $2^{20} \cdot (95)$

Ans. (1)

$$\text{Sol. } \sum_{r=0}^{20} r^2 {}^{20}C_r = \sum_{r=1}^{20} r \cdot {}^{20}C_r = \sum_{r=1}^{20} r \cdot 20 \cdot {}^{19}C_{r-1}$$

$$\Rightarrow 20 \sum_{r=1}^{20} (r-1+1) {}^{19}C_{r-1} = 20 \left(\sum_{r=1}^{20} (r-1) {}^{19}C_{r-1} + \sum_{r=1}^{20} {}^{19}C_{r-1} \right)$$

$$\Rightarrow 20 \left(19 \sum_{r=2}^{20} {}^{19}C_{r-2} + \sum_{r=1}^{20} {}^{19}C_{r-1} \right)$$

$$\Rightarrow (380)2^{18} + 20 \cdot 2^{19} \Rightarrow 2^{20} \cdot (95+10) = (105)2^{20}$$

3. If probability of independent events A and B are $P(A) = p$, $P(B) = 2p$ and probability of exactly one of A and B is $\frac{5}{9}$, then value of p is

- (1) $\frac{2}{5}$ (2) $\frac{1}{3}$ (3) $\frac{7}{12}$ (4) $\frac{1}{12}$

Ans. (2)

Sol. Probability (exactly one of A and B) = $\frac{5}{9}$

$$P(A) + P(B) - 2P(A)P(B) = \frac{5}{9}$$

$$p + 2p - 4p^2 = \frac{5}{9}$$

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$$36p^2 - 27p + 5 = 0$$

$$36p^2 - 12p - 15p + 5 = 0$$

$$\Rightarrow (12p - 5)(3p - 1) = 0$$

$$p = \frac{1}{3} \text{ or } \frac{5}{12}$$

4. The value of integration $\int_{-\frac{1}{2}}^{\frac{1}{2}} \left[\left(\frac{x-1}{x+1} \right)^2 + \left(\frac{x+1}{x-1} \right)^2 - 2 \right] dx$ is :

(1) $4 \ln \left(\frac{3}{2} \right)$

(2) $4 \ln \left(\frac{3}{4} \right)$

(3) $4 \ln \left(\frac{4}{3} \right)$

(4) $2 \ln \left(\frac{3}{2} \right)$

Ans. (3)

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$$\int_{-\frac{1}{2}}^{\frac{1}{2}} \sqrt{x+1} \sqrt{x-1} dx$$

$$= \int_{-\frac{1}{2}}^{\frac{1}{2}} \sqrt{\frac{-4x}{x^2-1}} dx$$

$$= \int_{-\frac{1}{2}}^{\frac{1}{2}} \frac{\sqrt{16x^2}}{(1-x^2)^2} dx$$

$$= \int_{-\frac{1}{2}}^{\frac{1}{2}} \frac{4|x|}{(1-x^2)^2} dx$$

$$= 8 \int_{-\frac{1}{2}}^{\frac{1}{2}} \frac{x}{1-x^2} dx = -4 \ln |1-x^2| \Big|_{-\frac{1}{2}}^{\frac{1}{2}} = 4 \ln \left(\frac{4}{3} \right)$$

5. Let $\text{Arg} \left(\frac{z+1}{z-1} \right) = \frac{\pi}{4}$. Then locus of z be a circle whose radius and centre respectively are:

(1) $\sqrt{2}$, (0, 1)

(2) $\sqrt{2}$, (0, -1)

(3) $\sqrt{2}$, (0, 0)

(4) 1, (1, 1)

Ans. (2)

Sol.



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$$\text{Arg} \left(\frac{z_0+1}{z_0-1} \right) = \frac{\pi}{2}$$

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$$\Rightarrow \left(\frac{z_0+1}{z_0-1} \right) = \frac{z_0+1}{z_0-1} e^{i\frac{\pi}{2}}$$

$$\Rightarrow \frac{z_0+1}{z_0-1} = i$$

$$\Rightarrow z_0+1 = iz_0-i$$

$$\Rightarrow (1-i)z_0 = -(1+i)$$

$$\Rightarrow z_0 = -\frac{(1+i)}{(1-i)}$$

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$$\Rightarrow z_0 = -\frac{1-i}{1-i}$$

$$\Rightarrow z_0 = -i$$

$$\Rightarrow \text{Centre } (0, -1) \text{ \& radius } = \sqrt{2}$$

6. If A and B are two square matrices of order 2×2 such that $A = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$; $B = \begin{bmatrix} 1 & 0 \\ i & 1 \end{bmatrix}$ (where $i = \sqrt{-1}$) and $A^i B^{2021} A = Q$, then the value of AQA^T is ?

(1) $\begin{bmatrix} 1 & 0 \\ i & 1 \end{bmatrix}$

(2) $\begin{bmatrix} 1 & 0 \\ 2021i & 1 \end{bmatrix}$

(3) $\begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$

(4) $\begin{bmatrix} 1 & 0 \\ 2020i & 1 \end{bmatrix}$

Ans. (2)

Sol.

$$B^2 = \begin{bmatrix} 1 & 0 \\ i & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ i & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 2i & 1 \end{bmatrix}$$

$$B^3 = \begin{bmatrix} 1 & 0 \\ i & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 2i & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 3i & 1 \end{bmatrix}$$

$$\dots \dots \dots$$

$$B^{2021} = \begin{bmatrix} 1 & 0 \\ 2021i & 1 \end{bmatrix}$$

$$\text{Given } A^i B^{2021} A = Q$$

$$AQA^T = A^i B^{2021} AA^T$$

$$\text{As } A = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \text{ So } A^T = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$AA^T = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I$$

$$\text{So } AA^T B^{2021} AA^T = B^{2021} I = B^{2021} = \begin{bmatrix} 2021 & 1 \\ & \end{bmatrix}$$

7. The mean of 20 observations is 10 and S.D. is 2.5. If one of the observation 25 is replaced by 35 then new mean and S.D. are α and $\sqrt{\beta}$ respectively, then ordered pair (α, β) is
- (1) (10.5, 36) (2) (10.5, 26) (3) (10.5, 25) (4) (10.5, 23)
- Ans. (2)

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Sol. $x_1 + x_2 + x_3 + \dots + x_{19} + 25 = 200$
 $\Rightarrow x_1 + x_2 + x_3 + \dots + x_{19} = 175$
 New mean = $\frac{x_1 + x_2 + x_3 + \dots + x_{19} + 35}{20} = \frac{175 + 35}{20} = 10.5$

$$\Rightarrow 2.5 = \sqrt{\frac{x_1^2 + x_2^2 + x_3^2 + \dots + x_{19}^2 + (25)^2}{20} - (10.5)^2}$$

$$\Rightarrow x_1^2 + x_2^2 + x_3^2 + \dots + x_{19}^2 = 1500$$

$$\text{New S.D.} = \sqrt{\frac{x_1^2 + x_2^2 + x_3^2 + \dots + x_{19}^2 + (35)^2}{20} - (10.5)^2}$$

$$= \sqrt{\frac{1500 + (35)^2}{20} - (10.5)^2}$$

$$= \sqrt{26}$$

$(\alpha, \beta) = (10.5, 26)$

8. If $\vec{a} = \hat{i} + \hat{j} + \hat{k}$, $\vec{b} = \hat{i} - \hat{k}$, $\vec{a} \times \vec{c} = \vec{b}$, $\vec{a} \cdot \vec{c} = 3$. Then the value of $[\vec{a} \vec{b} \vec{c}]$ is
- (1) $\sqrt{2}$ (2) -2 (3) 2 (4) $-\sqrt{2}$
- Ans. (2)

Sol. $[\vec{a} \vec{b} \vec{c}] = [\vec{c} \vec{a} \vec{b}]$
 $\Rightarrow (\vec{c} \times \vec{a}) \cdot \vec{b} = -\vec{b} \cdot \vec{b} = -2$

9. In a city, 89% people are suffered from diabetes and 98% people are suffered from heart diseases. If x% people are suffered from diabetes as well as heart diseases then the possible values of x cannot be lie in which of the following set:
- (1) {81, 83, 85, 86} (2) {82, 87, 88, 91} (3) {87, 88, 89, 90} (4) {88, 89, 92, 95}
- Ans. (1)

Sol. Let D and H is set of people suffered from diabetes and heart disease respectively.

$$n(H) = 98\%$$

$$n(D \cap H) = x\%$$

$$\max\{0, n(D) + n(H) - n(D \cup H)\} \leq n(D \cap H) \leq \min\{n(D), n(H)\}$$

So, $87\% \leq x \leq 89\%$

10. If $f(x+y) = 4xy$, then the value of $\frac{d^2y}{dx^2}$ at $x = 0$ is
- (1) 30 (2) 40 (3) 35 (4) 38
- Ans. (2)

Sol. when $x = 0$ then $y = 1$
 $f(x+y) = 4xy$
 $\Rightarrow x + y = e^{4xy}$

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$$\Rightarrow 1 + y' = e^{4xy} (4y + 4xy') \dots (i)$$

at (0, 1) $\Rightarrow y'(0) + 1 = 4 \Rightarrow y'(0) = 3$

Now, again differentiate equation (i)

$$\Rightarrow y'' = e^{4xy} (4y + 4xy')^2 + e^{4xy} (4y' + 4y' + 4xy'')$$

at (0, 1)

$$\Rightarrow y''(0) = 1 (4 \times 1 + 0)^2 + 1 (4 \times 3 + 4 \times 3 + 0)$$

$$\Rightarrow y''(0) = 16 + 24 = 40$$

$$\Rightarrow y''(0) = 40$$

11. If locus of a variable point P, whose sum of squares of distances from points (0,0), (0,1), (1,0) and (1,1)

is 18, is a circle of diameter d, then value of d^2 is equal to

Ans. 16.00

Sol. Let P (x,y)

$$x^2 + y^2 + (x-0)^2 + (y-1)^2 + (x-1)^2 + (y-0)^2 + (x-1)^2 + (y-1)^2 = 18$$

$$4x^2 + 4y^2 - 4x - 4y + 4 = 18$$

$$x^2 + y^2 - x - y - \frac{14}{4} = 0$$

$$\text{Centre } \left(\frac{1}{2}, \frac{1}{2}\right) \quad r = \sqrt{\frac{1}{4} + \frac{1}{4} + \frac{14}{4}} = 2$$

$$d = 2r = 2 \times 2 = 4$$

$$\text{So, } d^2 = 16$$

12. If $(1+y) \tan^2 x + \tan x \frac{dy}{dx} + y = 0$ and $\lim_{x \rightarrow 0^+} xy = 1$, then the value of $y\left(\frac{\pi}{4}\right)$ is

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Sol. $\frac{dy}{dx} + (1+y) \tan x = -y \cot x$

$$\frac{dy}{dx} + y (\tan x + \cot x) = -\tan x$$

$$\text{I.F.} = e^{\int (\tan x + \cot x) dx}$$

$$= e^{\int \frac{\tan^2 x + 1}{\tan x} dx}$$

$$= \tan x$$

$$y \cdot \tan x = \int -\tan^2 x dx + c$$

$$y \cdot \tan x = \int (1 - \sec^2 x) dx + c$$

$$y \cdot \tan x = x - \tan x + c$$

$$\lim_{x \rightarrow 0^+} xy = 1$$

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$$\Rightarrow \lim_{x \rightarrow 0^+} \left(\frac{x}{\tan x} \right) (x - \tan x + c) = 1$$

$$\Rightarrow 1(0 - 0 + c) = 1$$

$$\Rightarrow c = 1$$

Then the function is $y \cdot \tan x = x - \tan x + 1$

$$y\left(\frac{\pi}{4}\right) \Rightarrow y \cdot 1 = \frac{\pi}{4} - 1 + 1$$

$$y = \frac{\pi}{4}$$

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